Survey of Personal FM Systems in the Classroom: Consistency of Use and Teacher Attitudes

Capstone

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Anna Catherine Fry, B.A.

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Committee:

Gail Whitelaw, Ph.D., Advisor

Christine Goodman, Au.D.

Julie Hazelbaker, Ph.D

Abstract

The purpose of this study was to evaluate the current practices and attitudes of teachers towards the use and benefit of personal FM systems in the mainstream classroom for children with hearing loss. A 25-item online survey was sent to 2,006 elementary and middle school teachers in public schools in the Columbus, Ohio area. Participants were contacted three times via email requesting voluntary completion of the survey. Teachers were asked to respond about consistency of use and daily implementation of FM systems, as well as personal attitudes and knowledge about the benefit and use of the technology in the classroom. Overall, teachers reported that personal FM systems were utilized on a consistent basis, and that the devices were beneficial for children with hearing loss. However, responses indicated that teachers' knowledge was lacking on topics such as the implications of hearing loss on academics and daily listening checks and troubleshooting techniques for FM systems. These results support the need for more effective training and education of teachers on personal FM systems and hearing loss prior to beginning use with the device in order to help optimize the benefit and education of children with hearing loss.

Dedication

This project is dedicated to my family, especially my mom and dad, who supported me through 20 years of school and always encouraged me to do what I love.

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Vita

June 2006 ..... Bishop Watterson High School, Columbus, Ohio

June 2010 ..... B.A. Speech and Hearing Science, The Ohio State University

2010 to 2013 ..... Speech and Hearing Science Undergraduate Advisor, Department of Speech and Hearing Science, The Ohio State University

2012 to 2013 ..... Graduate Teaching Assistant, Department of Speech and Hearing Science, The Ohio State University

2013 to 2014 ..... Fourth Year Externship, Cincinnati Children's Hospital Medical Center, Cincinnati, Ohio

Fields of Study

Major Field: Audiology

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Chapter 1: Introduction

Approximately 11% of school-aged children experience some degree of hearing loss (Bess, Dodd-Murphy, Parker, 1998). Speech understanding can be compromised for children with hearing loss, due to the nature of the impairment which involves decreased audibility and less than optimal access to acoustic speech information. In the classroom environment, poor room acoustics due to excessive levels of background noise and reverberation can exacerbate these auditory difficulties (Flexer, 2004). Unfortunately, problems may persist even when the child utilizes well-fit hearing aids (Anderson, Goldstein, Colodzin, & Iglehart, 2005), and can ultimately impede learning and academic success.

Effective hearing and speech understanding in the classroom are such important components to learning and academic development that specifications have been set by the American National Standards Institute (ANSI) for the acoustical parameters of newly built classrooms, including limits for the levels of acceptable background noise and reverberation in the room (ANSI, 2010). These standards are designed to maximize access to acoustic information for all children in the classroom, and thus promote academic potentials. Unfortunately, classroom acoustics do not always meet these standards (Bradley & Sato, 2008; Crandell, 1993; Crandell & Smaldino, 2000), resulting in poor listening environments and potentially impeding learning. By increasing the level of a speech signal at the listener's ear by use of a remote microphone, frequency

modulated (FM) systems help to overcome the negative effects of poor acoustics and to improve potential for speech understanding in the classroom for children with hearing loss (Anderson et al., 2005; Hicks & Tharpe, 2002).

In any acoustic environment, children with hearing loss demonstrate poorer speech recognition skills compared to normal hearing peers (Crandell, 1993; Crandell & Smaldino, 2000; Finitzo-Hieber & Tillman, 1978). This is especially evident when the content of the speech signal is unfamiliar and no contextual cues are provided (Pittman, Vincent, & Carter, 2009), a situation often encountered during classroom instruction with the introduction of new vocabulary and learning material. This increased difficulty understanding speech has negative implications for a child's academic development, especially in the area of reading (Anita, Jones, Reed, & Kreimeyer, 2009). In addition, children with hearing loss often show decreased language abilities, difficulty with literacy (Most, Aram, & Andorn, 2006; Wake, Hughes, Poulakis, Collins, & Rickards, 2004) and delayed vocabulary development (Blamey et al., 2001; Gilbertson & Kamhi, 1995; Stelmachowicz, Pittman, Hoover, & Lewis, 2004).

Poor classroom acoustics create an additional barrier to listening and learning for children with hearing loss. These children have to expend more energy and concentration on speech recognition tasks, especially in the presence of noise (Hicks & Tharpe, 2002; Howard, Munro, & Plack, 2010). Even for children with minimal degrees of hearing loss or unilateral hearing loss, performance on language tasks is often poorer than peers with normal hearing, and speech perception becomes more difficult when placed in a classroom environment (Bess, Tharpe, & Gibler, 1986; Bess et al., 1998; Johnson, Stein, Broadway, & Markwalter, 1997; Lieu, Tye-Murray, Karzon, & Piccirillo, 2010).

While hearing aids make sounds more audible, a child with hearing loss often still has difficulty understanding speech in the presence of noise (Anderson et al., 2005). Consequently, the most important factor in providing these children with clear access to the speech signal is to make speech more prominent than noise, thus creating an advantageous signal-to-noise ratio (SNR). Children with hearing loss require a SNR that is 4-12 dB more favorable than the SNR needed by peers with normal hearing in order to obtain the same performance on speech recognition tasks (Crandell & Smaldino, 2000). By delivering the teacher's voice directly from a remote microphone to the child's ear-level receivers, personal FM systems create an improved SNR in the classroom and can provide greater benefit to speech understanding compared to hearing aids alone (Anderson et al., 2005; Boothroyd & Iglehart, 1998; Hicks & Tharpe, 2002).

Research clearly demonstrates the potential benefit personal FM systems provide to children with hearing loss in terms of understanding speech. The idea for the current study originated during clinical experiences with FM systems in the school setting. Observations suggested that many issues obstruct the effective use of the device, such as the student not bringing the system to class, inconsistent use, or the teacher not being provided with adequate instruction on the importance and proper use of a personal FM system. The American Academy of Audiology (AAA) developed clinical practice guidelines for use of Remote Microphone Hearing Assistance Technologies (RMHAT) with children, which includes personal FM systems for educational purposes. In the guidelines, topics are identified that should be covered with teachers prior to beginning use with an RMHAT device in the classroom, focusing on issues such as the components of the device, basic function, use, and benefit, listening checks, and troubleshooting

(AAA, 2008). The topics suggested in the RMHAT guidelines can be used as a foundation to help ensure teachers are being adequately educated about personal FM systems prior to beginning use.

There is paucity in the research regarding the consistency of personal FM system use in a mainstream classroom and the knowledge and attitudes of teachers towards this technology. The purpose of the current study is to evaluate the current practices and perceptions of teachers towards the use and benefit of personal FM systems in the mainstream classroom for children with hearing loss. With the ultimate objective of identifying areas in need of improvement in order to enhance quality of use, ensure teachers are comfortable with the device, and thus help optimize benefit and education of children with hearing loss, this study looks to answer the following research questions:

1. Do children with hearing loss who require a personal FM system in a mainstream classroom consistently use the device on a daily basis?
2. What are teachers' attitudes towards the benefit and daily use of a personal FM system for a child with hearing loss in a mainstream classroom, and who should be responsible for ensuring consistent use?
3. Using the AAA RMHAT guidelines as a reference, do teachers of mainstreamed children with hearing loss have adequate knowledge and information regarding the use, benefit, and troubleshooting methods for personal FM systems in the classroom?

Chapter 2: Literature Review

Both hearing loss and poor room acoustics are barriers to speech understanding for children in a classroom. A review of the literature demonstrates the impact of these variables on communication and ultimately academics, and highlights the educational benefits a personal FM system can provide for a child with hearing loss.

Hearing Loss and Academic Performance

According to Flexer (2004), a decrease in the ability to detect speech (due to decreased audibility from hearing loss, for example) will impede a child's ability to comprehend acoustic information in the classroom and ultimately affect learning. During communication, visual cues, such as facial expression and lip movement, supplement auditory information and can be helpful in understanding speech. However, when relying on auditory information alone, speech perception for children with hearing loss decreases about 5% for every 10 dB of hearing loss (Blamey et al., 2001). Results from a study by Pittman et al. (2009) suggested that the most robust difference in speech perception between children with normal hearing and hearing loss occurred when children were presented with unfamiliar auditory content. In the same study, children were also tested with meaningful and nonsense sentences to observe the effects of contextual cues on speech perception abilities. There was a significant difference in speech perception performance between children with normal hearing and hearing loss when presented with nonsense sentences, i.e. no contextual cues were provided. The performance gap was

much less pronounced when meaningful sentences and context were available (Pittman et al., 2009). The implications of these results can be seen in the classroom where novel and unfamiliar concepts, topics, and vocabulary are frequently presented to students during academic instruction. With limited knowledge of a topic, there is also a reduction in the amount of useful contextual cues available. In these situations, it is therefore presumed that children with hearing loss will perceive a significantly less amount of speech information compared to those with normal hearing. The following sections demonstrate the academic, personal, and social ramifications that become evident when the perception of classmates' and teachers' speech is impaired.

Language and Literacy

A child's hearing ability is related to the production of speech and pronunciation of corresponding speech sounds. Approximately 50% of children with hearing loss performed below grade level on pronunciation, written language, and oral expression (Wake et al., 2004). Additionally, any degree of hearing loss in the high frequencies can impede a child's production of affricates and fricatives (i.e. the "f" sound in "fish", the "s" sound in "snake", the "ch" sound in "chop", and the "j" sound in "just"), with greater difficulties and more sounds being affected as the degree of hearing loss increases (Elfenbein, Hardin-Jones, & Davis, 1994). Children with even moderate degrees of hearing loss also have significantly less frequent productions of possessives and plurals (-s morphemes) compared to peers with normal hearing (McGuckian & Henry, 2007).

A delayed rate of growth for language and vocabulary development is often seen in children with hearing loss compared to normal hearing peers (Blamey et al., 2001). On novel word identification tasks, children with hearing loss performed significantly poorer

than those with normal hearing. However, repetitions of the word and increases in intensity level of the stimulus presentation greatly benefited children, especially those with hearing loss, and improved performance on the identification of novel words (Stelmachowicz et al., 2004). Similarly, a study by Gilbertson and Kamhi (1995) looked at the ability of children with normal hearing and hearing loss to learn novel words of both simple and complex structures. For the complex novel words, children with hearing loss needed significantly more repetitions to learn the word. This novel word learning performance was significantly related to the children's scores on an assessment of receptive vocabulary abilities (Gilbertson & Kamhi, 1995). When looking at measures of language abilities, 50-66% of children with hearing impairment performed below average and would be considered as having language impairment (Gilbertson & Kamhi, 1995; Wake et al., 2004). Additionally, significantly more pragmatic errors were seen in children with hearing loss (Elfenbein et al., 1994).

Flexer (2004) noted that reading becomes a much more difficult task when a child has deficits in spoken language. Kindergarten children with hearing loss tend to have lower achievement scores in phonological awareness, letter identification, and vocabulary (Most et al., 2006). The negative impact of the hearing impairment on speech and language is also manifested in academic abilities, as these children tend to score about a half standard deviation below average on standardized achievement tests, and show the least amount of progress in reading (Anita et al., 2009).

Listening Effort

Apart from the academic ramifications, children with hearing loss often experience much greater fatigue during the school day due to the increased listening

effort required for them to understand a speech message. Hicks and Tharpe (2002) used dual task performance to determine the difference in listening effort between students with normal and impaired hearing. Children were asked to react to a light stimulus by pushing a button (secondary task) while doing a speech recognition task (primary task) at varying SNRs. Children with hearing loss had significantly longer reaction times to the light stimulus, suggesting that they were exerting more listening effort to the speech recognition task. Not only will this result in the child becoming more fatigued by the end of the day, but the student with hearing loss may also have more difficulty performing simultaneous tasks during classroom instruction, such as note taking (Hicks & Tharpe, 2002).

Social Issues

Hearing loss may also affect a child's social development. Elfenbein et al. (1994) noted that while speech production errors were seen in children with mild degrees of hearing loss, speech was typically more similar to children with normal hearing than to children with profound degrees of hearing loss. However, even though production errors were minimal, the children with hearing loss reported being self-conscious about the way they spoke and the reaction of peers, and a majority reported having difficulty making themselves be understood, at least on occasion (Elfenbein et al., 1994). Those children with hearing loss who have more intelligible speech were also shown to have better social competence and were perceived as being less lonely (Most, Ingber, & Heled-Ariam, 2012).

Classroom Acoustics

Poor room acoustics, such as excessive levels of background noise and reverberation, are also potential barriers to communication for any child in the classroom. Background noises inherent to a classroom, such as a fan or HVAC (heating, ventilation, and air conditioning) system, are low-frequency in nature and can mask higher-frequency components of speech (i.e. consonants) that contribute to clarity and understanding (Crandell & Smaldino, 2000). Reverberation refers to the reflection of speech signals off surfaces in a room. The reflected signals can overlap with the direct signal as it reaches the listener's ear and distort or mask the speech (Crandell & Smaldino, 2000). Speaker-to-listener distance also plays a role in speech understanding in noisy and reverberant environments, such as a classroom. Not only does the loudness of a speech signal decrease as the distance between a speaker and listener increases, but reverberated signals will start to interfere with the direct signal and degrade speech when distance between the listener and speaker exceeds a critical distance (Crandell & Smaldino, 2000).

More important than the level of the background noise in characterizing classroom acoustics is actually the SNR of speech at the child's ear, which is the difference in loudness between the speaker's voice reaching the child's ear (the signal) and the background noise. A higher SNR is more ideal for speech understanding because there will be less competition between the signal and background noise. The SNR suggested for optimal speech understanding in a classroom is +15 dB (Nelson & Soli, 2000), meaning that the intensity of the speech signal is 15 dB greater than the overall background noise.

Given the importance of speech understanding in academics, the ANSI developed guidelines to specify the limits of background noise and reverberation times of newly built classrooms (ANSI, 2010). Background noise consists of all sound coming from within a furnished, but unoccupied, classroom and also includes sounds from outside the room (ANSI, 2010). Internal noise comes from sources such as fans, ventilation systems, and people moving and talking within the classroom. External noise results from outside sources such as transportation vehicles and outdoor environmental sounds. Reverberation time is the amount of time required for the level of a steady sound to decay by 60 dB (ANSI, 2010). In a classroom, sounds are reverberated off multiple surfaces such as walls, chairs, desks, and cabinets. The ANSI Standard (2010) states that in a classroom, background noise cannot exceed 35 dBA and reverberation time cannot exceed 0.6 seconds. Maintaining a background noise level below 35 dBA allows a normal teacher's voice to reach children at all locations in the classroom at the ideal SNR of +15 dB (Nelson & Soli, 2000). Therefore, these acoustic parameters set by ANSI are meant to promote optimal access to speech for all children in the classroom and lessen the adverse effects of background noise, reverberation, and distance on speech understanding.

Poor Classroom Acoustics

Despite the ANSI standards, average classroom acoustics often do not meet the recommended parameters (Bradley & Sato, 2008). Background noise levels can reach around 51 dB in a typical classroom (Crandell, 1993), with SNRs ranging from only -7 dB to +5 dB, and reverberation times as high as 0.4-1.2 seconds (Crandell & Smaldino, 2000). Finitzo-Hieber and Tillman (1978) looked at the effects of SNRs and

reverberation levels that are commonly found in classroom environments on monosyllabic word recognition abilities in children. Testing was performed at SNRs of +12 dB, similar to what is specified by the current ANSI guidelines, +6 dB, a SNR level that is similar to what is commonly found in classrooms, and 0 dB, which is representative of a poor classroom environment. Reverberation times of 0.4 seconds and 1.2 seconds were used, to represent a condition that is within ANSI specifications and a poor condition that is often found in classrooms, respectively. Even for children with normal hearing, performance was significantly reduced in the presence of these adverse conditions. The effects of noise alone showed that the addition of any noise (even at +12 dB SNR) caused a significant decrease in word discrimination abilities. Performance at +12 dB SNR for children with normal hearing was 89% and was still considered good, however, it was significantly poorer than performance in quiet (95%). There was an overall decrease of 34% in word discrimination performance from quiet to the 0 dB SNR condition. The effects of reverberation alone indicated that when reverberation time was 0.4 seconds, which is within the ANSI specifications, word discrimination performance was 93%, which is not significantly different from performance when reverberation was not present. However, when reverberation times were increased to 1.2 seconds, a condition that is commonly found in classrooms and is characteristic of a poor acoustic environment, word discrimination performance decreased significantly, to 77%. This study also showed that even for children with normal hearing, the combination of background noise and reverberation resulted in an additional decrease in monosyllabic word recognition when compared to the effect of either variable alone (Finitzo-Hieber & Tillman, 1978).

With classroom SNRs often only reaching +5 dB, as noted above, it is evident that any child may experience difficulty understanding speech during educational instruction. Speech recognition decreased to approximately 50% when SNRs reached -4 dB and performance on secondary tasks was greatly reduced compared to when in a quiet environment (Howard et al., 2010), meaning that more effort was being devoted to listening to speech. As children are often required to multitask during classroom instruction (i.e. taking notes while the teacher is talking), greater listening effort required for speech understanding in poor SNR environments will mean less attention can be used for secondary tasks, such as note taking, and potentially contribute to academic difficulties.

In general, compared to adults, all children require a more advantageous SNR for optimal speech understanding. Bradley and Sato (2008) found an age-related difference in the SNR required for the majority of students in a certain grade to achieve 95% performance on a speech-understanding task. Students in sixth grade only required a +15 dB SNR for the task while a +20 dB SNR was needed for students in first grade. In the development of speech recognition, different parts of the speech signal (i.e. vowels and consonants) reach adult-like performance at different ages. Speech understanding may therefore be affected to some extent until the child can master proper recognition of all speech components. Additionally, background noise in the classroom masks acoustic cues of a spoken message, especially consonant sounds which contain less energy than vowels, and compromises the developing speech perception abilities (Crandell & Smaldino, 2000). With the addition of reverberation, consonant identification does not reach adult-like performance until later in the teenage years (Johnson, 2000). Thus, with

increasing reverberation times, younger children require an even higher SNR in order to achieve 50% performance on speech recognition tasks (Neuman, Wroblewski, Hajicek, & Rubinstein, 2010). Excessive amounts of reverberation in the classroom can also have negative effects on language abilities, as it has been shown that children had significantly better phonological processing, including identification, storage, and analysis of speech, in classrooms with short reverberation times (Klatte, Hellbruck, Seidel, & Leistner, 2010).

Hearing Loss and Poor Classroom Acoustics

It is estimated that 11% of school-aged children have some degree of hearing loss (Bess et al., 1998), and for these children, speech understanding difficulties due to poor classroom acoustics are exacerbated by the impairment. Flexer (2004) explained how the combination of these two variables may ultimately affect learning and academic development for children with hearing loss. The facilitation of learning is essentially dependent upon a child's ability to comprehend a message, and in order to comprehend a child must first be able to accurately detect speech signals from the teacher and classmates. Poor acoustic conditions in a classroom may negatively affect transmission of a speech signal, and without amplification, the decreased audibility inherent to hearing loss may further impact a child's ability to detect the speech, therefore impeding comprehension and potentially academic performance. Children with hearing loss also have less access to distance hearing. Incidental learning is therefore more limited for children with hearing loss than for those with normal hearing, who are able to absorb information from overhearing speech that may occur at a distance. Children with hearing

loss often need to attend to speech more consciously in order to hear and learn from it (Flexer, 2004).

Compared to those with normal hearing, people with hearing loss require a 4-12 dB more favorable SNR in the presence of noise and a 3-6 dB more favorable SNR in excessive reverberation in order to achieve equivalent speech recognition performance (Crandell & Smaldino, 2000). Results from the study by Finitzo-Hieber and Tillman (1978) were previously discussed in terms of the effects of noise and reverberation on speech understanding for children with normal hearing. This study also compared monosyllabic word discrimination abilities for children with normal hearing and hearing loss in background noise and reverberation conditions often found in classroom environments. For children with hearing loss, performance decreased from 88% in quiet with no reverberation to 78%, 66%, and 42% at +12 dB, +6 dB, and 0 dB SNRs respectively. This overall decrease of 46% across the various background noise levels shows a significant decrease in word recognition abilities for children with hearing loss in SNRs that are commonly found in educational environments. When looking at the effect of reverberation only, performance decreased from 88% in no noise and no reverberation to 79% and 62% in 0.4 second and 1.2 second reverberation conditions respectively. Overall, as reverberation times increased to 1.2 seconds, word discrimination performance decreased significantly (by 26%). Compared to children with normal hearing, these scores are approximately 14-15% worse. When evaluating word recognition abilities for children with hearing loss in an acoustic environment similar to a typical classroom, with both background noise and reverberation, performance was shown to decrease further in comparison to performance with just one of the adverse

conditions. These scores were again shown to be significantly lower than those of the children with normal hearing, at all combinations of SNRs and reverberation times (Finitzo-Hieber & Tillman, 1978).

Even children with unilateral (hearing loss in only one ear) and minimal degrees of hearing loss experience difficulties in the classroom. In a review of current literature, Lieu (2010) reported that 0.1-5% of school-aged children have a unilateral hearing loss (UHL). Consideration of binaural advantages, or the benefits of hearing with two ears, opposes the common belief that these children can perform adequately with only one good hearing ear. Maximum access to acoustic information from both ears allows for binaural summation, sound localization, and better hearing in noise, which are all beneficial for children in the classroom. The phenomenon of binaural summation, an increase in the perceived level of sound due to equal auditory input from both ears, can improve perception by 3-10 dB depending on presentation level, with a greater advantage occurring when the signal is presented at a higher sensation level (Lieu, 2010). This increased perception of the level of sound when using two ears makes listening easier and improves word recognition by up to 18% (Lieu, 2010). Sound localization, the ability to identify the direction of a sound source, is very important for communication in the classroom as it helps to identify the location of the speaker, allowing for the use of visual along with auditory cues. Children with UHL have poorer localization skills when compared to those with normal hearing acuity bilaterally (Bess et al., 1986), as they are less sensitive to timing and intensity differences between ears, an essential skill for localization. Binaural squelch, the use of spatial cues to separate speech from noise, helps for understanding speech in noise and also relies on auditory information being

received from two ears (Lieu, 2010). Bess et al. (1986) found that compared to those with normal hearing, children with UHL have greater difficulty understanding nonsense syllables, especially in adverse listening conditions, such as a classroom with background noise, even when speech is presented to the better hearing ear. A study by Ruscetta, Arjmand, and Pratt (2005) similarly found that children with UHL required a more favorable SNR compared to those with normal hearing on speech understanding in noise tasks, especially when the signal was not directed to the side of the better hearing ear. With decreased auditory input from one ear, children with UHL are less able to make use of these binaural advantages, which can affect classroom performance. Those with UHL have significantly lower scores on language tests compared to peers with normal hearing (Lieu et al., 2010). Teachers are able to perceive these academic difficulties and reported that while children with UHL tend to pass in several academic areas, scores are significantly lower than children with normal hearing (Dancer, Burl, & Waters, 1995). In a longitudinal study of children with UHL, behavioral problems and delays in overall academic abilities were often seen (Lieu, Tye-Murray, & Fu, 2012). Additionally, parents reported that children with UHL exhibited educational and social difficulties and teachers reported that these children often had trouble with attention, organization, and working independently (Lieu et al., 2012). Therefore, while children with UHL may ultimately "get by" academically, they are often faced with additional obstacles and difficulties due to the hearing loss.

It has been reported that 1 in 20 school-aged children have a minimal hearing loss (MHL), which nearly doubles the prevalence of hearing loss when compared to statistics that only include children with moderate and severe hearing loss (Bess et al., 1998).

Children with MHL have significantly more difficulty with speech recognition compared to those with normal hearing, especially when SNRs are degraded (Crandell, 1993). At a +6 dB SNR, children with normal hearing and MHL were able to perceive above 80% of speech. As the SNR decreases to -6 dB, differences in speech perception abilities became more obvious. Children with normal hearing performed at about 75% and those with MHL perceived less than 50% of the material (Crandell, 1993). As SNRs within a classroom can often be as poor as -7 dB (Crandell & Smaldino, 2000), even a minimal degree of hearing loss has potential to make understanding educational instruction more difficult. Specifically, Johnson et al., (1997) found that even in quieter classroom situations, children with minimal high frequency hearing loss, a population that includes the significant prevalence of noise-induced hearing loss (Niskar et al., 2001), needed auditory assistance in order to perceive high frequency features of speech, which aid in the clarity and intelligibility of speech. Teachers have also noted that children with mild to moderate degrees of hearing loss required more instances of additional prompting after directions were given to the entire class during classroom instruction and that these children responded inaccurately more often than peers with normal hearing (Borders, Barnett, & Bauer, 2010). Children with MHL had lower overall evaluations of academic performance, and a perceived higher risk of academic failure (Bess et al., 1998).

FM Systems

As previously mentioned, a +15 dB SNR is recommended for clear communication and speech intelligibility in a classroom, which should allow access to optimal listening for children at all locations in the room, taking into consideration the higher SNR needed for young children, children with English as a second language, and

children with hearing loss (Nelson & Soli, 2000). Unfortunately, this ideal condition is not always achieved in the classroom, thus impeding speech understanding especially for children with hearing loss. An FM system is an assistive listening device consisting of a microphone worn by the speaker, which transmits the speech signal directly to receivers worn on the listener's ear. Personal FM systems are used to help improve speech understanding by creating a more advantageous SNR, thus eliminating adverse effects of noise, reverberation, and distance on the transmission of a speech signal (Johnston, John, Kreisman, Hall, Crandell, 2009).

Benefits of Personal FM Systems

The goal of hearing aids as intervention for hearing loss is to provide audibility of sounds that the child is missing. However, the ability to understand speech may be further affected by background noise, reverberation, and distance between the speaker and listener, regardless of the audibility of the speech. In the classroom environment, separating an important speech message from background noise may remain a difficult task for children with hearing loss, even with appropriate amplification. While hearing aid technology continues to improve in terms of noise reduction and speech enhancement, it is not able to function as effectively as a normal auditory system. Ching, van Wanrooy, Dillon, and Carter (2011) found that children who wore hearing aids in the classroom were less able to use spatial cues to help with speech understanding in noise, even when the speech was spatially separated from the noise. This suggests that children with hearing aids may require a higher SNR and extra auditory assistance in order to understand speech as well as normal hearing peers in the classroom.

Several studies have compared speech perception performance using hearing aids alone and a combination of hearing aids and assistive listening devices. Boothroyd and Iglehart (1998) looked at speech perception abilities of teenagers with severe to profound hearing losses in quiet (+20 dB SNR) and noisy (+5 dB SNR) situations. Personal FM systems provided some benefit in quiet, but the greatest and most significant FM advantage was seen in the presence of background noise. In the noisier condition, subjects improved an average of 30% on phoneme recognition tasks when using the personal FM system and hearing aid combined, compared to use of the hearing aid alone. In a typical classroom with noise and reverberation, speech recognition performance for children with hearing loss was 82% with hearing aids alone (Anderson et al., 2005). Hicks and Tharpe (2002) found similar results and also noted that while this is improved performance to the unaided condition, it is still significantly lower than normal hearing peers. When fit with a personal FM system in conjunction with the hearing aid, speech recognition performance increased significantly to 94% for the children with hearing loss (Anderson et al., 2005). Directional microphones on hearing aids are another option that may be used to help children with speech understanding in the classroom. This function decreases the level of sound coming from behind the listener, with the assumption that noise will be located behind and important speech information in front of the listener. Lewis, Crandell, Valente, and Horn (2004) evaluated the reception threshold for sentences in noise and the difference in benefit between personal FM systems and directional microphones in adults with hearing loss. Results showed that speech perception was significantly better when using the personal FM system coupled to the hearing aids compared to when the hearing aids were used alone, even with directional

microphones. The ability of the FM system to deliver a direct speech signal to the listener's ear has a clear benefit in overcoming background noise compared to simply reducing the perceived level of the noise. Additionally, a binaural fit of the FM receivers and hearing aids resulted in the best overall performance in noise, revealing a binaural advantage of 3 dB (Lewis et al., 2004).

The ear-level personal FM system also shows benefit over other forms of the assistive listening device, such as soundfield FM speakers. Soundfield systems, work in much the same way as a personal FM system by transmitting the talker's voice from a microphone directly to receivers, which in this case are speakers positioned around the classroom. While the advantage of this system is providing a more direct speech signal to all students around the classroom, it does not provide significant speech perception benefit for children with hearing loss above using hearing aids alone (Anderson et al., 2005), as is seen with personal systems. Personal FM systems are also reported to be easiest to listen with, preferred by teachers, and most accepted by classmates (Anderson et al., 2005).

In addition to the benefit to overall speech perception, personal FM systems can facilitate incidental learning for children with hearing loss by overcoming background noise and allowing for easier speech understanding from a distance. By increasing the SNR, the FM system helps keep the child's attention throughout the day, thus allowing the child to miss less information and use less energy for listening (Flexer, 2004). Teachers also reported benefits such as the need for less repetition of instructions, an increase in attention span, increased participation, improved comprehension of oral directions, and improved concentration and confidence when children were using FM

systems compared with children with hearing loss who do not utilize the technology (Purdy, Smart, Baily, & Sharma, 2009).

Degree of hearing loss and performance on speech perception tasks in quiet should not be used to predict a child's performance in the classroom or potential benefit from a personal FM system. Anderson et al. (2005) demonstrated that even children with mild to moderate degrees of hearing loss show benefit and improvement in speech perception performance when using a personal FM system compared to a soundfield FM system. Additionally, personal FM systems have shown to allow for significant improvements in speech recognition for children with severe to profound UHL (Kenworthy, Klee, & Tharpe, 1990).

Based on teacher report, children who utilized cochlear implants (CI) possessed the necessary skills to be successful in a mainstream school and were not always perceived as being educationally at risk (Damen, van den Oever-Goltstein, Langereis, Chute, & Mylanus, 2006). However, several studies revealed that communicating in the classroom continued to be problematic at times for these children. Damen et al. (2006) found that children with CIs had significantly poorer skills in participation and appropriate communication behavior in the classroom compared to peers with normal hearing. Additionally, reports from teachers indicated that children with CIs were perceived to have poorer abilities on expressive and receptive aspects of communication (Damen et al., 2006). For children with CIs who struggle with communication, especially related to academics, personal FM systems are a good option for facilitating speech understanding in the classroom. When using an FM system in addition to a CI, speech recognition in noise performance was significantly better, improving speech

recognition thresholds by up to 20 dB (Schafer & Thibodeau, 2006). Performance on speech in noise tasks was best when a child was fit with binaural implants or bimodal devices (CI in one ear and hearing aid in the other ear) and could also utilize the personal FM system binaurally. However, even children with a monaural CI fitting demonstrated significant improvement for speech in noise recognition with the addition of a monaural FM system on the CI side. Additionally, benefit from the monaural CI and FM system fitting was significantly higher compared to children who were receiving binaural input, whether from a binaural or bimodal fit of the CI, but did not utilize an FM system (Schafer & Thibodeau, 2006). These results demonstrate the additional need and benefit of a device that enhances the SNR in order to improve speech recognition in the classroom for children with CIs.

Educational Legislation for Children with Hearing Loss

Given the communication difficulties that accompany hearing loss and the potential impact of this impairment on academic performance, legislation has been set in place to ensure that children with hearing loss are provided with appropriate accommodations to facilitate learning. The Individuals with Disabilities Education Act (IDEA) was developed to ensure that all students with a disability, including those with hearing loss, are provided an appropriate public education in the least restrictive environment, in order to ensure access to optimal academic success (Salathiel, Steele, & Edwards, 2010). A child with hearing loss must meet certain requirements for eligibility of coverage under IDEA. While the specific hearing loss requirements vary by state, the general guidelines indicate that the child must have some degree of documented hearing loss that negatively affects academic performance (Salathiel et al., 2010). Under IDEA, a

child with hearing loss must be monitored periodically by the school to ensure that the treatment option, including a personal FM system, is functioning properly and providing academic benefit for the child (AAA, 2008). Once a child with hearing loss is determined to be eligible for IDEA, the Individual Educational Plan (IEP) is established in order to identify accommodations necessary for the child (Salathiel et al., 2010). A personal FM system is often recommended for children with hearing loss as it provides a more optimal listening condition and enhances communication by overcoming the negative effects of background noise, reverberation, and distance from the speaker, which can occur in a classroom and interfere with speech understanding (Salathiel et al., 2010).

FM System Training

For a child with hearing loss, the successful implementation of a personal FM system in the classroom requires a team approach from the child, audiologist, and educational staff (Salathiel et al., 2010). As teachers and other school personnel have contact with the student and personal FM system during every school day, it is imperative to understand the importance and proper function of the technology in order for the child to receive maximum benefit. An essential component of the fitting plan should therefore include training or education for the teacher, and it is suggested that the audiologist be the professional responsible for providing this session (ASHA, 2002). The RMHAT clinical practice guidelines (AAA, 2008), lists topics that should be covered with teachers and educational staff prior to beginning use with assistive listening devices such as personal FM systems. The following issues are suggested to be presented to facilitate proper FM system implementation in the classroom (AAA, 2008):

1. Basic implications of hearing loss

2. Basic function of the device
3. Appropriate use of device and features
4. Expectations: benefits and limitations of the device including when to use and when not to use
5. Listening check and basic troubleshooting
6. Reporting of a suspected malfunction
7. Advocacy
8. Classroom orientation to HAT

The American Speech-Language-Hearing Association (ASHA) has similarly developed guidelines for the fitting and monitoring of FM systems (ASHA, 2002). It was noted that while the student using the personal FM system should be responsible for self-monitoring and reporting any noticeable problems with the device, it is also necessary for someone with normal hearing to ensure the system is working properly (ASHA, 2002). The teacher must be able to perform a visual inspection and listen to the device for sound quality, repair minor problems, and know when to report the need of a repair (ASHA, 2002). This highlights the importance of covering the aforementioned training topics with teachers and educational staff prior to beginning use with the device, as the quality of use is what improves outcomes (AAA, 2008) and makes FM system use more effective. Along with covering these training topics, hands on demonstrations should be considered (ASHA, 2002), and support for teachers, follow-up, and monitoring should be available throughout the school year to ensure the teacher understands the benefit of the FM system, it is being utilized properly by both the student and the teacher, and to address problems as soon as they arise (AAA, 2008).

Previous Research

There is paucity in the research regarding the consistency of personal FM system use in a mainstream classroom and the knowledge and attitudes of teachers towards this technology. The information that is available supports the need for further research and improvements in the implementation of personal FM systems in the classroom. In 1981, it was reported that very few teachers felt they had been provided with sufficient information concerning amplification technology or the best way to educate children with hearing loss in the mainstream environment (Matkin, 1981). Around the same time, a national survey of teachers also determined that many believed they needed more in-service training sessions centered around classroom amplification options (Sinclair & Freeman, 1981). In regards to knowledge of and exposure to hearing loss, teachers and special educators reported understanding that children with hearing loss may have trouble with the production of certain sounds, that hearing aids do not make hearing "normal," and batteries are the power source of hearing aids (Lass et al., 1985). The list of items related to hearing loss and hearing aids that teachers and special educators reported not knowing included topics such as the medical treatment of hearing loss, limitations of lip-reading, the effect of simply speaking louder to a child with hearing loss, and where or who to see if a hearing aid is needed (Lass et al., 1985). The majority of teachers also reported never having an academic course on hearing loss or hearing disorders (Lass et al., 1985). These results suggest that the typical teacher is unfamiliar with several important issues concerning hearing loss in children.

A similar study to the present investigation, completed in 1991 by Maxon, Brackett, and van den Berg, collected data on the selection and purchase of FM systems,

the attitudes of special educators toward the use of personal FM systems in the classroom, and child descriptive data. Participants included speech-language pathologists, audiologists, and teachers of the hearing-impaired. Data was collected for two samples, first during the years of 1981-82, and second during the years of 1988-89. Based on special educator report during both time samples, results showed that only about half of FM systems were checked daily to ensure proper functioning, with the other half of systems being checked "when needed." Overall, it was reported that FM systems were beneficial for children with profound hearing loss, however, there were mixed attitudes about the usefulness of the technology for children with milder degrees of hearing loss. There was also a general belief that when compared to elementary-aged children, students in junior high and high school were less likely to want to use an FM system during classroom instruction. About two-thirds of the respondents in this study had issues with appearance of the receivers, the part of the FM system worn by the student, due to the belief that parents do not want their child to look different. Additionally, about half of the special educators reported they were opposed to using the FM system and did not want to make the effort to use it, possibly because they did not completely understand the benefits of the FM system for the student (Maxon et al., 1991). Despite these views, the majority of participants disagreed with the statement "FM systems are more trouble than they are worth" (Maxon et al., 1991).

An updated collection of the information regarding personal FM system use in the mainstream school environment would allow for comparisons of the consistency or differences in the use and knowledge of the technology over time. Additionally, the appearance and physical fit of personal FM systems has been reformed and quality of

speech transmission has improved. As this updated information should be used to help improve the practice of personal FM system implementation in the classroom, it is necessary to base current conclusions and interventions on data relating to more recent technology and attitudes towards personal FM systems. The goal of the present study is to first determine the consistency of current personal FM system use in schools. Second, information will be obtained regarding teachers' attitudes and knowledge of personal FM system use and troubleshooting procedures to determine if the topics specified in the RMHAT guidelines (AAA, 2008) are being communicated to teachers. This will help identify issues that need to be included in training sessions with teachers in order to improve the quality of personal FM system use, take full advantage of the benefits, ensure teachers are comfortable with the use of this technology, and thus help maximize the education of children with hearing loss.

Chapter 3: Methods

The protocols in this research study were approved by the Social and Behavioral Sciences Institutional Review Board at The Ohio State University. An online survey was used to collect data on the opinions of teachers regarding the use of personal FM systems in the classroom for children with hearing loss.

Survey

A 25-item survey was developed based on a review of the current literature and firsthand observations made while checking FM systems in local schools as part of the clinical education component of the Doctor of Audiology program at The Ohio State University. The final survey (Appendix A) contained two sections: the qualifying questions and the content questions. The qualifying portion of the survey contained four questions that were used to identify those teachers who have had experience with a personal FM system in the classroom and who met the requirements to continue participation in the research study. The content portion of the survey contained 21 questions divided into three categories: daily implementation and use of personal FM systems, attitudes towards the benefit and use of the device, and knowledge of the function and troubleshooting methods for personal FM systems.

The content questions in the current investigation were modeled off a questionnaire presented in a similar study by Maxon and colleagues (1991), as both studies presented similar research goals. The questions addressed topics related to the

consistency of FM system use for the population of children with hearing loss in mainstream classroom settings, the perceived responsibility of the teacher to implement the daily use of the device, the degree of training and amount of information provided to teachers regarding the use of FM systems in the classroom, teachers' knowledge of the use, benefit, and troubleshooting methods for FM systems, and teachers' attitudes towards the benefit of a personal FM system. There is a lack of recent research on this topic, so a goal of the current study is to compare and expand on the results obtained in the 1991 study by Maxon and colleagues.

The RMHAT clinical practice guidelines (AAA, 2008) were used as an additional source for questions in the current survey. Included in the guidelines is a list of suggested topics that should be covered during FM system training for parents, caregivers, and/or teachers. This list was used to guide the development of Question #22 in the present survey, which asks participants to identify the specific topics that they are knowledgeable in or that were covered during a training session for personal FM systems (Appendix B shows a comparison of the topics provided in the RMHAT guidelines (AAA, 2008) and Question #22). Ultimately, the content questions were designed to identify integral topics related to personal FM system use in the classroom that are indicated by teachers as lacking from training sessions.

Close-ended questions were used to collect responses and obtain specific, objective information about teachers' experience with personal FM systems in the classroom. This allowed for the ability to analyze and characterize data based on percentages. However, each question also provided the participant with the option of adding a comment about individual experiences pertaining to the question. As there is

currently no universal protocol for implementing FM systems in the classroom, these responses provided insight into teachers' current attitudes and knowledge of FM systems and helped identify topics that are not being addressed sufficiently but would be beneficial in future training sessions for personal FM system use.

A pilot survey was sent to four teachers not participating in the study in order to obtain feedback on the content and assess the face validity of the survey. These teachers were given a brief explanation of the purpose of the survey and were asked to comment on the content, relevance of questions, and ease-of-use of the survey. The initial version was a 24-item survey and included the same content as the final version, with the exception of Question #10, regarding technical issues with personal FM systems. This question was added in response to feedback received from the pilot survey. Responses to the pilot survey were not included in the final analysis. The revised survey was judged to have good face validity based on feedback from the teacher review.

Subjects

Subjects were teachers recruited from elementary and middle schools within nine public school districts in Central Ohio, including Big Walnut, Olentangy, Dublin, Westerville, Upper Arlington, Gahanna, Canal Winchester, Reynoldsburg, and Marysville school districts. The school districts included in this study were chosen because they all utilize an audiologist from The Ohio State University Speech-Language-Hearing Clinic, on a contractual basis, as the designated educational audiologist for all schools within the district. In this system, the educational audiologist is responsible for providing the teacher and student with an orientation to personal FM system use in the classroom, along with periodic visits throughout the school year for monitoring or

reported problems. As the audiologist is not permanently located in the school district, support is also received from school personnel, such as intervention specialists, who can more accurately monitor and provide notification of a student's progress with the FM system and manage or report issues. A list of 2,006 potential participants was compiled by searching each elementary and middle school's website for teachers' publicly provided email addresses. If no information was provided in terms of the teacher's grade or subject area, the teacher's email address was automatically added to the list. If a grade and/ or subject area was listed for a particular teacher, the teacher's email address was only added to the list if the teacher taught in a grade between Kindergarten and 8th grade and if the teacher taught a primary academic subject (i.e. teachers of special subject areas such as art, music, physical education, etc., were excluded from the list). Participation was restricted to teachers with these characteristics for several reasons. Personal observation has revealed that grades Kindergarten through 8th grade are where FM systems are most often used and each teacher is typically with a student for a more extended period of time throughout the day (compared to a high school teacher, for example), allowing for more experience, consistent exposure to the FM system, and the ability to report on daily use with more detail. Additionally, there are similarities in classroom layouts and protocols for how the FM systems are used and taken care of throughout these grades. A better comparison can therefore be made between results than if teachers of special subjects or high school students were to be included. Contact information was not provided or available for every teacher in the selected school districts, so the final list is a compilation of only those teachers whose email addresses were made publicly available on the school website.

The two purposes of the full survey were first to determine how many teachers have had experience with personal FM systems in the classroom, and second to gain information about personal FM system use. In order to collect data and answer the research questions proposed by this study, the qualifying portion of the survey sought to identify those participants who met the following requirements:

1. The teacher must have experience teaching a student with hearing loss who required the use of a personal FM system at some point in the teaching career.
2. The teacher's experience with the personal FM system must have been in a mainstream school environment (i.e. not in a hearing impaired educational program, a school for the deaf, etc.)
3. The student with whom the personal FM system was used must have been in a grade between Kindergarten and 8th grade.

Teachers meeting these requirements were asked to complete the full, content portion of the survey as well.

Procedures

An electronic version of the survey was generated and distributed via Survey Methods, an online survey tool. The 2,006 potential subjects were initially contacted via a recruitment email through the Survey Methods email deployment system that asked for voluntary participation in a research survey and included a link to the survey. The recruitment email is provided in Appendix C. The survey remained open for four weeks and all participants were contacted three times during this period. The initial email was sent when the survey was opened and two follow-up/ reminder emails were sent after two weeks and three days before the end of the survey. The reminder emails are also

provided in Appendix C. No other contact was made with participants. The survey was made anonymous through Survey Methods so that responses would not be linked to individual email addresses and identifying information was not requested.

Chapter 4: Results

Electronic surveys were sent out through the Survey Methods email deployment system to 2,006 teachers in nine of the school districts in the Columbus, Ohio area. Due to several emails being unable to be delivered, there were ultimately 1,986 potential participants that received an email with a link to the survey. Of these teachers, 183 responded to the present survey, resulting in a response rate of 9.2%. Of the total respondents, 174 teachers (95%) completed the survey either until all content questions were answered (if the participant qualified for this portion of the survey), or until the survey was automatically ended after not meeting a requirement in the qualifying portion. Only nine respondents (5%) began the survey and voluntarily opted out before answering all applicable questions.

Of the total 183 respondents, 94 teachers (51%) met the requirements of the study to answer the content portion of the survey. To qualify, the teacher had to be teaching, or previously taught, a student with hearing loss who required the use of a personal FM system. This experience had to have been with a student in a grade between Kindergarten and 8th grade and in a mainstream educational environment.

Qualifying questions

Approximately half of respondents (54%; 99 of the total 183 respondents to the survey) reported having used a personal FM system during classroom instruction at some point in the teaching career. The majority of the teachers (97%; 93 of the 96 respondents

to this question) had experience using the personal FM system in a mainstream educational environment. All of the teachers had used the device for a student in a grade between Kindergarten and 8th grade. The majority of the teachers (83%) had the most recent experience with a personal FM system within the past 5 years (a combination of those teachers who reported using it within the current or past school year, or at least less than five years ago), with 42% reporting using the device during the current academic school year (Figure 1). This suggests that the teachers have likely utilized more current FM system devices and digital hearing aid technology.

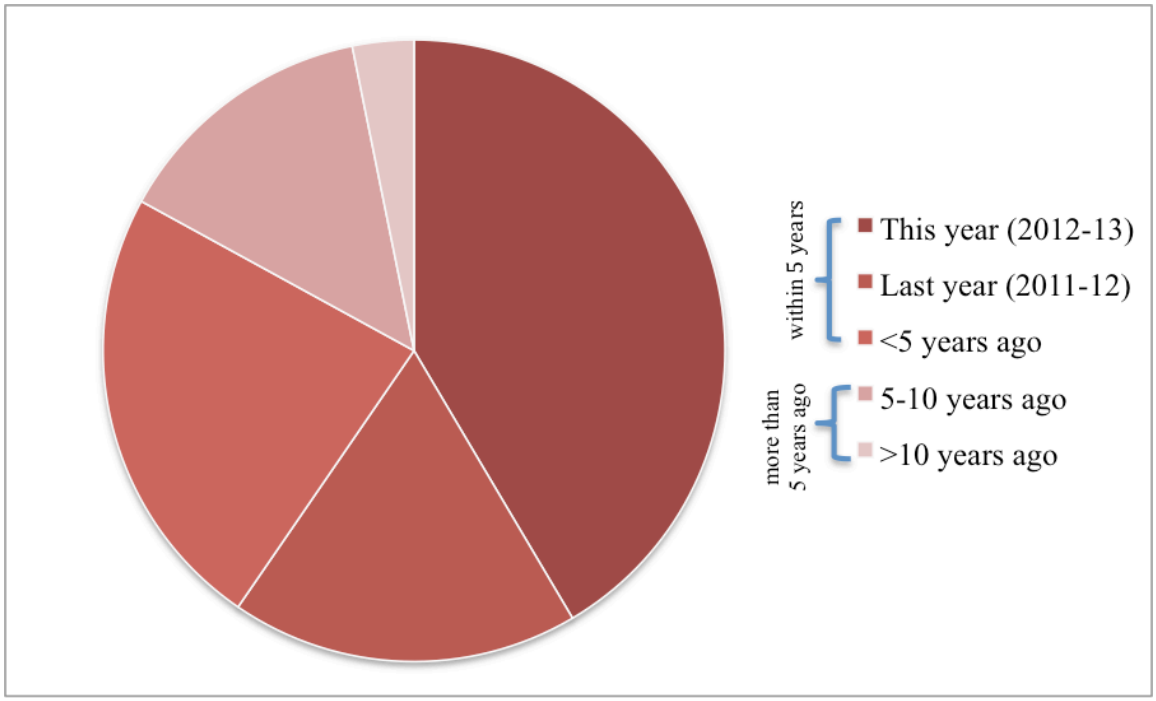

Figure 1. Most recent experience with a personal FM system

Content questions

Ninety-four teachers completed the qualifying portion of the survey and met the three requirements for continuing on with the content portion of this survey. Of these teachers, 88 (94%) completed the content questions for this research study. There were 88 respondents to each content question in the survey, indicating that all teachers who began answering content questions finished and provided an answer to the full survey. The following results are reported for these 88 respondents and the responses to the content questions of the survey.

Daily Implementation and Consistency of Use

The majority of teachers (78%) reported that students who require an FM system during classroom instruction wear the device consistently, on a daily basis. Figure 2 shows a breakdown of the percentage of time in a typical week that teachers indicate students wear the personal FM system. As seen in this figure, 44% of teachers reported that students wear the FM system 100% of the time in a typical week. An additional 24% reported that students wear the FM system 75% of the time. Only 15% of teachers reported that students wear the FM system less than 25% of the time or never in a typical week. If a student is not wearing the FM system during classroom instruction, 78% of the respondents reported that they would remind the student to use it. The majority of teachers (72%) agreed that it was not accurate that children with more mild degrees of hearing loss did not need to utilize the FM system as consistently as those with more severe degrees of hearing loss.

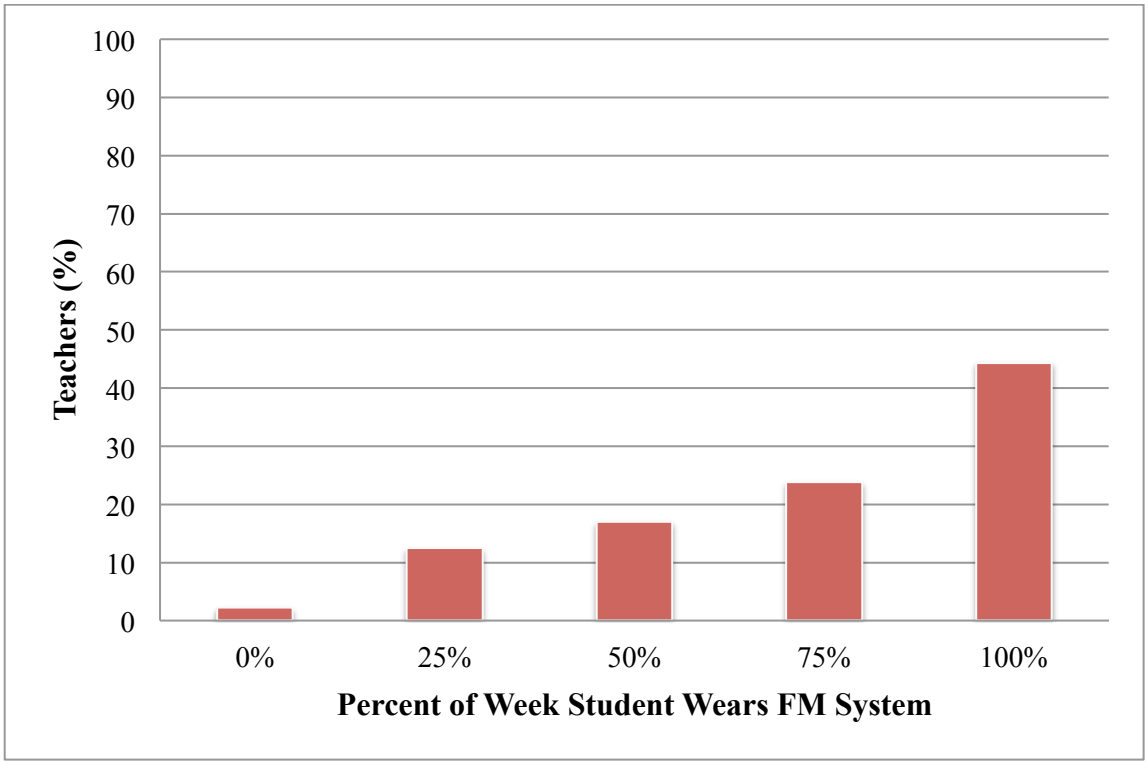

Figure 2. Teacher report of percent of week student wore FM system

Teachers were asked about some common reasons that a student may not wear the personal FM system during the day. Figure 3 shows the number of teachers who reported experiencing each of these issues. The most common reasons for students not wearing the FM system as reported by teachers were related to the student forgetting to bring the device to class (36%) or instances of the teacher forgetting to remind the student to wear the device (22%), as well as the perceived negative personal and social reactions to the student wearing the FM system (34% and 28% respectively). It is important to note that 25% of teachers reported students not utilizing the FM system due to the device being broken. About half of the respondents (57%) have also noticed a trend in FM system use decreasing as students move to higher grades.

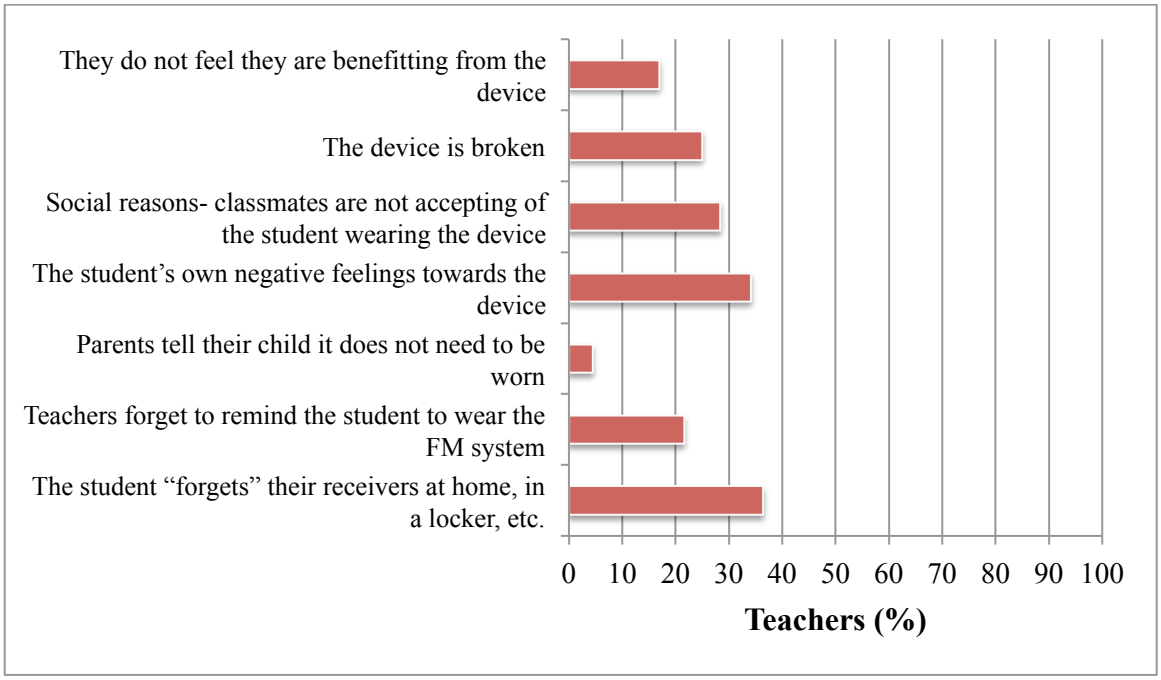

Figure 3. Common reasons student did not utilize FM system

In terms of the daily functioning, charging, and use of the FM system, 52% of the respondents indicated that in their experience the student took responsibility to ensure that the FM system was worn and functioning properly, and 68% of the respondents reported the student would indicate to school personnel if the FM system were to stop working during the school day. Figure 4 demonstrates how often respondents reported experiencing "technical issues" that resulted in the student not being able to use the FM system during classroom instruction. Thirty percent of teachers reported never having technical problems with FM systems in the classroom. However, 43% reported have technical issues at least a few times a year (either once or 2-3 times per year), 17% reported monthly technical issues (either once or 2-3 times per month), and 10% reported weekly technical issues with personal FM systems (either once or 2-3 times per week).

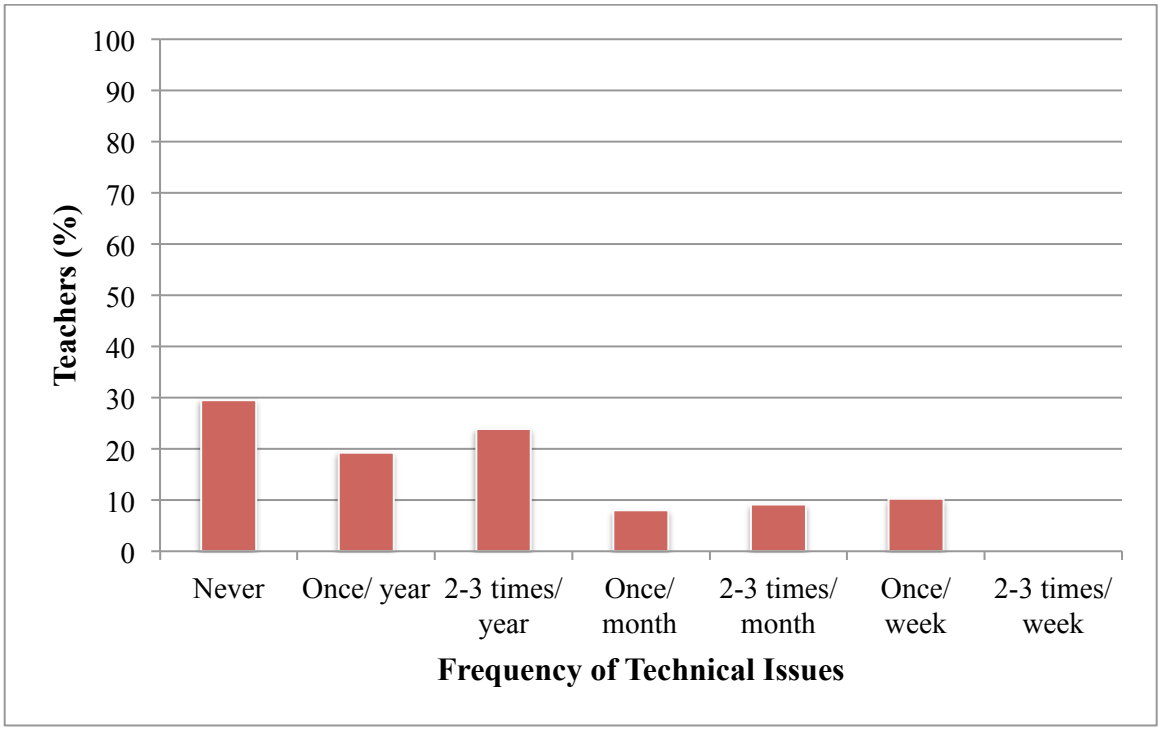

Figure 4. Teacher report of personal FM system technical issues

Teacher Attitudes

All respondents reported that personal FM systems were beneficial to students with hearing loss and 85% reported it was important for the student to wear the device at all times during classroom instruction. Ninety-one percent of responding teachers reported that students with hearing loss performed better academically when using the FM system and 61% reported that use of the FM system resulted in better social interactions for the student with hearing loss. The majority of teachers indicated that it should be the student's responsibility to ensure that the FM system is being worn at all times during classroom instruction and that the FM system is functioning properly each day (88% and 82% respectively). Many respondents did, however, acknowledge that the teacher should help to remind the student about the use and function of the FM system as

well. Only 10% of teachers reported that it was bothersome to wear the FM transmitter (microphone) during classroom instruction.

Teacher Knowledge

Only about half (51%) of teachers who have used a personal FM system reported having received training for the device prior to beginning use. Of those teachers that did receive some form of training, 76% believed that the training they received was beneficial and 24% indicated that the training was not beneficial. Over half of teachers (61%) reported not receiving any follow-up training or instruction on personal FM systems throughout the school year. However, some of these teachers (32%) reported that this type of training would have been helpful and they would have liked for it to be offered. Figure 5 lists the topics of personal FM system use that are identified in the RMHAT guidelines (AAA, 2008) as being important in the training and instruction of teachers who will use this device during classroom instruction. The percentage of teachers who reported having covered each topic during a training session is depicted in the figure. Of the 12 items suggested, seven were identified by more than 50% of teachers as being an area of knowledge. Less than 50% of teachers reported being knowledgeable about the remaining five topics suggested in the RMHAT guidelines. It is encouraging to see that the majority of teachers (82% and 75% respectively) reported knowledge of two very important topics pertaining to FM system use in the classroom: 1) the purpose of the FM system in increasing the ratio of speech compared to background noise level and 2) identification of both teacher- and student-worn components in the FM system. More than half of respondents also indicated covering topics such as the benefit of the FM system for children with hearing loss (65%), how to connect the student's

receivers to the hearing aids (51%), the purpose and function of various buttons on the device (57%), the contact person for troubleshooting or repair of the FM system (53%), and the daily charging and storage protocol for the system (67%). Sixty-five percent of teachers reported knowing where the FM system is to be stored each night after school, and 63% indicated that they know how to charge the FM system. However, 42% of respondents reported receiving no training at all for the FM system, and based on teacher's responses it is evident that for those who did receive training, several topics are lacking from current training sessions with FM systems. Less than half of teachers reported having knowledge of topics such as the basic impact of hearing loss on speech understanding (33%), the expectations about the benefit and limitations of the FM system (35%), and when to use and not to use the device (49%). Very few teachers (26% and 37% respectively) reported knowledge of two very important topics in ensuring proper function of the FM system: 1) how to perform a listening check and 2) basic troubleshooting techniques that can be used in the classroom if the FM system is not functioning properly.

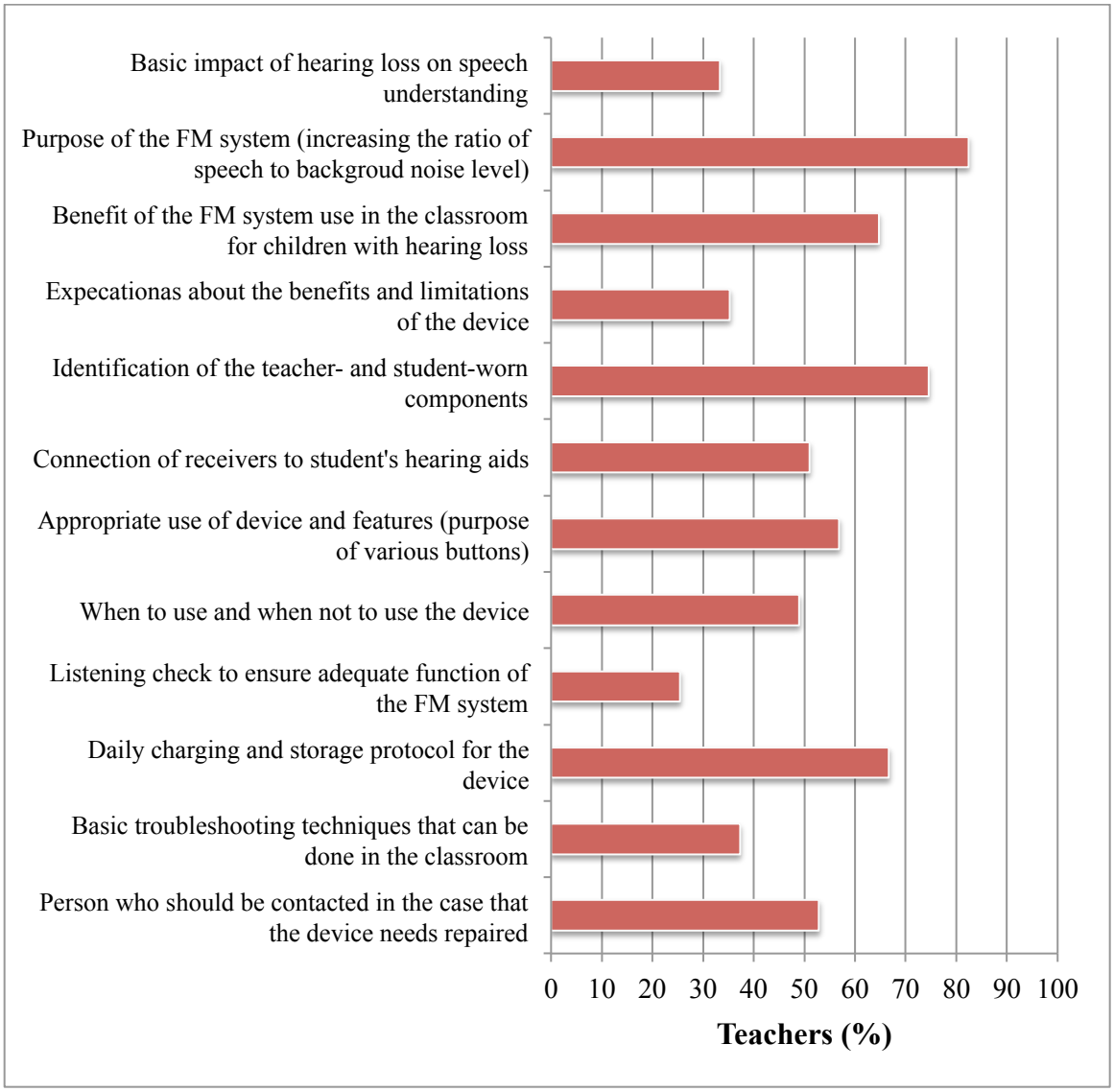

Figure 5. Topics covered in training session (based on RMHAT guidelines, AAA, 2008)

Chapter 5: Discussion and Conclusions

The purpose of the current study was to determine the consistency of personal FM system use in the classroom, as a student's benefit from the technology can only be obtained if it is implemented properly. Based on teachers' experiences, it was reported that the majority of students utilized the FM system consistently, at least 75% of the time during a typical school week. Most teachers indicated that they would remind a student to wear the FM system if it was not being utilized during classroom instruction. The most commonly identified reasons for students not utilizing the FM system during class were related to the device being forgotten, the perceived negative reactions the student received while wearing the device, components of the system not functioning properly, and occasions when the student was not reminded to use the device. These findings are consistent with anecdotal observations made by the researcher during clinical experience, based on conversations with students and teachers during visits to local schools to check the function of personal FM systems in classrooms. Results also support feedback from a teacher in the pilot survey, which suggested that technical issues with FM system components are often encountered and affect the consistency and ease of use. The majority of teachers reported having technical issues during the school year, although the frequency ranged from a few times per year to a few times per week. Over half of teachers did report that if there was a problem with the functionality of the FM system, the student took responsibility for solving or notifying the teacher of the problem.

While the results obtained in this study were generally positive with regards to consistent FM system use in the classroom, it is important to remember that the use of an FM system is often written into the IEP document for a child with hearing loss. Many teachers reported that, although the teacher should help remind the student, it was ultimately the student's own responsibility to wear the device daily and ensure that it was functioning properly. However, under IDEA the school must ensure that a student with a disability is provided with the necessary assistive technology as required in the IEP (Salathiel et al., 2010). Teachers must therefore take responsibility in the enforcement and proper implementation of personal FM systems in the classroom.

An additional purpose of the study was to evaluate the attitudes and knowledge of teachers in regards to the benefit and use of personal FM systems in the classroom for children with hearing loss, in order to assess the comprehensiveness of current beliefs and practices. Overall, teachers reported very positive attitudes toward the use of personal FM systems for children with hearing loss. Participants indicated that the technology was beneficial in the classroom, and that the student was perceived to perform better academically with the assistive listening device. Teachers also recognized that it was important for the student to utilize the device at all times during classroom instruction, and reportedly were willing to wear the transmitter microphone while teaching. In addition to academic benefit, 61% of teachers reported a perception of improved social interaction for the student with hearing loss while utilizing the FM system.

While these results suggested overall consistent use and a generally positive attitude toward the benefit of a personal FM system in the classroom for a student with hearing loss, some negative results regarding knowledge and understanding of the

assistive listening device were identified. Only about half of teachers reported receiving some form of training on FM systems prior to using the device, and of those teachers that did receive training, over half of them reported they did not receive follow-up education. Results indicated several topics that are important in ensuring optimal benefit and proper use of the FM system (AAA, 2008), but do not currently seem to be communicated to teachers adequately in preparation for using the device in the classroom. Only a small portion of teachers in this study admitted having knowledge of the basic impact of hearing loss on speech understanding. This statistic could present as a barrier to consistent FM system use in the classroom, as the ultimate goal of the device is to provide a more optimal speech signal and improve understanding. It is essential that the teacher of a student with hearing loss understand how the impairment affects the child's comprehension and learning in the classroom, as this speaks to the potential benefit of an FM system and the importance of consistent implementation. Additionally, results suggested that a vast majority of teachers did not know how to perform a listening check of the device or basic troubleshooting techniques, despite the fact that technical issues were previously identified as a frequent barrier to consistent FM system use. While an ultimate goal in FM system use should be for the student to take part in the responsibility of ensuring proper function, ASHA suggests that it is also necessary for someone with normal hearing to listen and check the system to verify proper function (ASHA, 2002), such as the teacher. These results support the need for more effective training and education of teachers on personal FM systems and hearing loss, prior to beginning use with the device, in order to help optimize the benefit and education for children with hearing loss.

Comparison to Previous Research

As the available research on the topic presented in this study is limited and outdated, several questions in the survey were based on or related to a questionnaire from a similar study completed in 1991 by Maxon and colleagues. This allowed for comparisons of improvement or differences in FM system use in the classroom over time. Maxon et al. (1991) collected data regarding several areas of FM system use over two sampling periods, 1981-82 and 1988-89. For both samples it was found that the majority of special educators were provided with an in-service training after the school district obtained the FM system, however, follow-up training was usually not provided throughout the school year. These results are consistent with findings of the current study, despite the idea that in order to completely understand the "auditory needs of the hearing-impaired child, including use and maintenance of amplification," education and training is needed more than just on an annual basis (Maxon et al., 1991). Nearly all special educators reported performing equipment checks of the FM system, however, the majority did this on an inconsistent basis or only when the student indicated a problem (Maxon et al., 1991). Correspondingly, in the current study, the majority of teachers were not proficient in performing daily listening checks and basic troubleshooting techniques for the FM system.

Several attitudes towards FM systems also appear to have remained consistent over time. Based on results of both studies, it was encouraging to find that personal FM systems were perceived by educators as being beneficial to students with hearing loss and there was a general agreement with the idea that FM systems are beneficial to all children with hearing loss, not merely those with more profound degrees of hearing loss.

Unfortunately, social attitudes toward the physical appearance of the FM system have remained negative. Respondents in the Maxon et al. (1991) study indicated a dislike that the device made the student look different from other classmates, and in the current study it was reported that a student's own negative feelings and classmates not accepting the FM system were principle reasons that a student did not utilize the FM system during class. Additionally, participants of both studies reported a perceived trend in FM systems being rejected by students in higher grade levels.

Some positive differences were noted between results of the two studies and suggest an improvement in the acceptance and implementation of the device in the classroom. Based on responses collected by Maxon and colleagues (1991) about half of educators in the regular education environment did not want to wear the FM system transmitter microphone or make the effort to implement daily use of the device. Results also indicated a perception that parents did not want the child to look different from peers. In contrast, only 10% of teachers in the present study reported that the transmitter microphone was bothersome to wear during classroom instruction and parental influence was no longer perceived as a noteworthy reason that a student did not utilize the FM system during class. A possible explanation for changes in the acceptance of FM system use in the classroom over time is the modifications that have been made to the physical appearance of the teacher-worn transmitter, as well as a better understanding and implementation of the requirements of IDEA and IEPs that has occurred over the years.

Limitations and Future Directions

The major limitations of this study relate to the response rate of the survey (9.2%). One explanation for the low response rate is the time of the school year that the

survey was distributed. The survey was sent during the spring, with the intent of gaining responses from teachers later in the school year, after they presumably had experience with a personal FM system for more than half of the year and could better report on typical practices. Unfortunately, some teachers may have been on spring break, without access to email, when the survey was sent. To help overcome this, a four-week time period was allotted for the collection of survey responses, with reminder emails being sent out at several intervals during this time frame to give teachers an opportunity to access the survey at some point that did not occur during a break. One teacher commented that because it was getting close to the end of the school year, there was not enough time to complete the survey, as there were many other mandatory activities related to the job. It could be argued, however, that teachers are very busy at many points during the school year, and there may not be an optimal time period for reaching all teachers while still obtaining meaningful responses about FM system experiences. Another possible explanation for the low response rate is that some teachers may not have been motivated to complete the survey if they had no experience or familiarity with personal FM systems. While the purpose of the qualifying questions in the survey was to include this group of teachers in the overall responses collected, it is possible that the survey was often dismissed after reading the title. Despite a somewhat low response rate, the overall number of responses was reasonable. One goal of the survey was to collect information and opinions of teachers that could be utilized in the future development of educational training materials for teachers preparing to work with a child with hearing loss and personal FM systems. The feedback obtained remains valuable and useful in identifying important topics that should be covered in training.

Information from this survey was obtained from teachers in nine different school districts, all with similar relationships to an audiologist. Although all schools were within the Columbus, Ohio area, it is presumed that each district contains slightly different demographics and teachers with differing amounts of exposure to children with hearing loss and personal FM systems. Results could therefore be generalized and used to enhance training of teachers in other states and areas. It would be interesting in the future to compare results obtained from this study to responses of teachers in a school for the hearing-impaired or a district with more consistent access to an educational audiologist or professional working in the school who is able to monitor FM system use more closely. It is hypothesized that these teachers would have more experience and access to resources concerning personal FM systems and would therefore present with more effective practices with the device in the classroom. A future analysis could also separate results further to observe differences in teachers' attitudes and practices for Kindergarten through 4th grade compared to 5th through 8th grade, as students are often with one teacher more consistently in the early grades.

Additionally, after obtaining and analyzing responses from the survey, it was clear that more questions could have been presented in order to enhance knowledge on the current topic. For example, some participants indicated that a training session would not be helpful for using FM systems in the classroom. This was an unexpected response and it would be interesting to question why, possibly because a teacher had previous experience with the assistive listening device or more consistent access to a knowledgeable professional housed in the school or district who is able to monitor FM system use more regularly than the remote educational audiologist is able to do?

Similarly, who was training provided by and what should be added to the training to make it more beneficial? The survey in the current study did provide the opportunity for respondents to add an open-ended comment after each question in order to better document certain experiences with a personal FM system for a child with hearing loss in the classroom. These responses were not discussed in the results of the study, due to the large amount and variance of individual comments for each question, as these would have been difficult to summarize and were not crucial to the primary purpose of the study. Comments were obtained as additional information, but would again be helpful feedback in the development of educational material for working with personal FM systems in the classroom.

Children with hearing loss are fit with personal FM systems as a means to provide a more favorable listening environment in the classroom, with the ultimate goal of facilitating learning. As demonstrated earlier, research clearly shows the benefit to speech understanding and academics that is provided to children with hearing loss through a personal FM system. During analysis, a thought was presented that teachers may feel too busy with classroom responsibilities and accommodations for other children, thus making it difficult to properly implement use of an FM system for a child with hearing loss. Presumably, if a teacher understands the benefit of the technology, it would not be a burden to make this accommodation, thus highlighting the importance of training teachers prior to beginning use with the FM system. The purpose of collecting the information from this survey was to ensure teachers have an adequate understanding of the importance and function of personal FM systems. As the quality of use is what improves outcomes (AAA, 2008), it is recommended that a teacher receive training or

guidance on benefit and proper use prior to working with a personal FM system. In the future, information gained from this study regarding the reported knowledge and attitudes of teachers towards FM systems in the classroom should be considered and integrated into education that is developed for those preparing to work with a child with hearing loss. Topics such as daily listening checks, basic troubleshooting methods, and the educational impact of hearing loss, which were identified as lacking from current practices, should be sure to be covered in the training provided to teachers. It is also recommended that support for teachers, follow-up, and monitoring be available throughout the school year (AAA, 2008), as results of the current study suggest this is not current practice. Ultimately, it would be desirable to develop a universal protocol of training materials for teachers preparing to utilize a personal FM system and for all teachers to have access to educational materials, whether online or in person, throughout the year to aid in proper use and common issues. As an integral factor in the implementation of a personal FM system, it is essential that educators understand not only how to use and troubleshoot the device, but also the importance of consistent use and potential academic benefit it provides to the student with hearing loss.

References

American Academy of Audiology (2008). AAA clinical practice guidelines: Remote microphone hearing assistance technologies for children and youth birth–21 years. Retrieved from www.audiology.org /resources/documentlibrary/documents/ hatguideline.pdf.

American National Standards Institute & the Acoustical Society of America (2010). American National Standard: Acoustical Performance Criteria, Design Requirements, and Guidelines for Schools, Part 1: Permanent Schools (ANSI/ASA S12.60-2010/ Part 1).

American Speech-Language-Hearing Association (2002). Guidelines for fitting and monitoring of FM systems. Available from http://www.asha.org/policy/GL2002-00010.htm.

Anderson, K.L., Goldstein, H., Colodzin, L., & Iglehart, F. (2005). Benefit of S/N enhancing devices to speech perception of children listening in a typical classroom with hearing aids or a cochlear implant. Journal of Educational Audiology, 12, 16-30.

Anita, S.D., Jones, P.B., Reed, S., & Kreimeyer, K.H. (2009). Academic status and progress of deaf and hard-of-hearing students in general education classrooms. *Journal of Deaf Studies and Deaf Education, 14(3),* 293-311.

Bess, F.H., Dodd-Murphy, J., & Parker, R.A. (1998). Children with minimal sensorineural hearing loss: prevalence, performance, and functional status. Ear & Hearing, 19(5), 339-354.

Bess, F.H., Tharpe, A.M., & Gibler, A.M. (1986). Auditory performance of children with unilateral sensorineural hearing loss. Ear & Hearing, 7(1), 20-26.

Blamey, P.J., Sarant, J.Z., Paatsch, L.E., Barry, J.G., Bow, C.P., Wales, R.J., Wright, M., Psarros, C., Rattigan, K., & Tooher, R. (2001). Relationships among speech perception, production, language, hearing loss, and age in children with impaired hearing. *Journal of Speech, Language, and Hearing Research, 44,* 264-285.

Boothroyd, A. & Iglehart,F. (1998). Experiments with classroom amplification. *Ear and Hearing, 19(3),* 202-217.

Borders, C.M., Barnett, D., & Bauer, A.M. (2010). How are they really doing? Observation of inclusionary classroom participation for children with mild-to-moderate deafness. *Journal of Deaf Studies and Deaf Education, 15(4),* 348-357.

Bradley, J.S. & Sato, H. (2008). The intelligibility of speech in elementary school classrooms. *J Acoust Soc Am, 123(4),* 2078-2086.

Ching, T.Y.C., van Wanrooy, E., Dillon, H., & Carter, L. (2011). Spatial release from masking in normal-hearing children and children who use hearing aids. *J. Acoust. Soc. Am., 129(1),* 368-375.

Crandell, C.C. (1993). Speech recognition in noise by children with minimal degrees of sensorineural hearing loss. Ear & Hearing, 14(3), 210-216.

Crandell, C.C. & Smaldino, J.J. (2000). Classroom acoustics for children with normal hearing and with hearing impairment. Language, Speech, and Hearing Service in Schools, 31, 362-370.

Damen, G.W.J.A., van den Oever-Goltstein, M.H.L., Langereis, M.C., Chute, P.M., & Mylanus, E.A.M. (2006). Classroom performance of children with cochlear implants in mainstream education. *Annals of Otology, Rhinology, & Laryngology, 115(7),* 542-552.

Dancer, J., Burl, N.T., & Waters, S. (1995). Effects of unilateral hearing loss on teacher responses to the SIFTER. *American Annals of the Deaf, 140(3),* 291-294.

Elfenbein, J.L., Hardin-Jones, M.A., & Davis, J.M. (1994). Oral communication skills of children who are hard of hearing. *Journal of Speech and Hearing Research, 37,* 216-226.

Finitzo-Hieber, T. & Tillman, T. (1978). Room acoustics effects on monosyllabic word discrimination ability by normal and hearing impaired children. *Journal of Speech and Hearing Research, 21,* 440-458.

Flexer, C. (2004). The impact of classroom acoustics: Listening, learning, and literacy. *Seminars in Hearing, 25(2),* 131-140.

Gilbertson, M. & Kamhi, A.G. (1995). Novel word learning in children with hearing impairment. *Journal of Speech and Hearing Research, 38,* 630-642.

Hicks, C.B. & Tharpe, A.M. (2002). Listening effort and fatigue in school-age children with and without hearing loss. Journal of Speech, Language, and Hearing Research, 45, 573-584.

Howard, C.S., Munro, K.J., & Plack, C.J. (2010). Listening effort at signal-to-noise ratios that are typical of the school classroom. *International Journal of Audiology, 49,* 928-932.

Johnson, C.E. (2000). Children's phoneme identification in reverberation and noise. *Journal of Speech, Language, and Hearing Research, 43,* 144-157.

Johnson, C.E., Stein, R.L., Broadway, A., & Markwalter, T.S. (1997). "Minimal" high-frequency hearing loss and school age children: Speech recognition in a classroom. *Language, Speech, and Hearing Services in Schools, 28,* 78-85.

Johnston, K.N., John, A.B., Kreisman, N.V., Hall, J.W., Crandell, C.C. (2009). Multiple benefits of personal FM system use by children with auditory processing disorder (APD). *International Journal of Audiology, 48,* 371-383.

Kenworthy, O.T., Klee, T., & Tharpe, A.M. (1990). Speech recognition ability of children with unilateral sensorineural hearing loss as a function of amplification, speech stimuli, and listening condition. *Ear & Hearing, 11(4),* 264-270.

Klatte, M., Hellbruck, J., Seidel, J., & Leistner, P. (2010). Effects of classroom acoustics on performance and well-being in elementary school children: A field study. *Environment and Behnavior, 42(5),* 659-692

Lass, N.J., Carlin, M.F., Woodford, C.M., Campanelli-Humphreys, A.L., Judy, J.M., & Hushion-Stemple, E.A. (1985). A survey of classroom teachers' and special educators' knowledge of and exposure to hearing loss. *Language, Speech, and Hearing Services in Schools, 16,* 211-222.

Lewis, M.S., Crandell, C.C., Valente, M., & Horn, J.E. (2004). Speech perception in noise: Directional microphones versus frequency modulation (FM) systems. *J Am Acad Audiol, 15,* 426-439.

Lieu, J.E.C. (2010). Children with unilateral hearing loss. *Seminars in Hearing, 31(4),* 275-289.

Lieu, J.E.C., Tye-Murray, N., & Fu, Q. (2012). Longitudinal study of children with unilateral hearing loss. *The Laryngoscope, 122,* 2088-2095.

Lieu, J.E.C., Tye-Murray, N., Karzon, R.K., & Piccirillo, J.F. (2010). Unilateral hearing loss is associated with worse speech-language scores in children. Pediatrics, 125, e1348-e1355.

McGuckian, M. & Henry, A. (2007). The grammatical morpheme deficit in moderate hearing impairment. *Int. J. Lang. Comm. Dis., 42(S1),* 17-36.

Matkin, N.D. (1981). Amplification for children: Current status and future profiles. In F.H. Bess, B.A. Freeman, & J.S. Sinclair (Eds.), *Amplification in Education*, p. (192-202). Washington, DC: A.G. Bell Publishers.

Maxon, A.B., Brackett, D., & van den Berg, S.A. (1991). Classroom amplification use: A national long-term study. *Language, Speech, and Hearing Services in Schools, 22,* 242-253.

Most, T., Aram, D., & Andorn, T. (2006). Early literacy in children with hearing loss: A comparison between two educational systems. *The Volta Review, 106(1),* 5-28.

Most, T., Ingber, S., & Heled-Ariam, E. (2012). Social competence, sense of loneliness, and speech intelligibility of young children with hearing loss in individual inclusion and group inclusion. *Journal of Deaf Studies and Deaf Education, 17(2),* 259-272.

Nelson, P.B. & Soli, S. (2000). Acoustical barriers to learning: Children at risk in every classroom. *Language, Speech, and Hearing Services in Schools, 31,* 356-361.

Neuman, A.C., Wroblewski, M., Hajicek, J., & Rubinstein, A. (2010). Combined effects of noise and reverberation on speech recognition performance of normal-hearing children and adults. *Ear & Hearing, 31(3),* 336-344.

Niskar, A.S, Kieszak, S.M., Holmes, A.E., Esteban, E., Rubine, C., & Brody, D.J. (2001). Estimated prevalence of noise-induced hearing threshold shifts among children 6 to 19 yearsof age: The Third National Health and Nutrition Examination Survey, 1998-1994, United States. *Pediatrics, 108,* 40-43.

Pittman, A., Vincent, K., & Cater, L. (2009). Immediate and long-term effects of hearing loss on the speech perception of children. J Acoust Soc Am, 126(3), 1477-1485.

Purdy, S.C., Smart, J.L., Baily, M., & Sharma, M. (2009). Do children with reading delay benefit from the use of personal FM systems in the classroom? International Journal of Audiology, 48, 843-852.

Ruscetta, M.N., Arjmand, E.M., & Pratt, S.R. (2005). Speech recognition abilities in noise for children with severe-to-profound unilateral hearing impairment. *International Journal of Pediatric Otorhinolaryngology, 69,* 771-779.

Salathiel, K., Steele, J., & Edwards, D. (2010). Advocating for optimal listening in the classroom. *Seminars in Hearing, 31 (3),* 241-251.

Schafer, E., & Thibodeau, L. (2006). Speech recognition in noise in children with cochlear implants while listening in bilateral, bimodal, and FM-system arrangements. *American Journal of Audiology, 15,* 114–126.

Sinclair, J.S. & Freeman, B.A. (1981). The status of classroom amplification in American education. In F.H. Bess, B.A. Freeman, & J.S. Sinclair (Eds.), *Amplification in Education*, p. (205-215). Washington, DC: A.G. Bell Publishers.

Stelmachowicz, P.G., Pittman, A.L., Hoover, B.M., & Lewis, D.E. (2004). Novel-word learning in children with normal hearing and hearing loss. *Ear & Hearing, 25,* 47-56.

Wake, M., Hughes, E.K., Poulakis, Z., Collins, C., & Rickards, F.W. (2004). Outcomes of children with mild-profound congenital hearing loss at 7 to 8 years: A population study. *Ear & Hearing, 25,* 1-8.

Appendix A: Survey

Qualifying questions to determine if participant meets requirements for the study

1. In your career, have you ever taught a student with hearing loss who required the use of a personal FM system during classroom instruction?
    a. Yes
    b. No→ exit survey
2. Did the instruction of the student with hearing loss and use of the personal FM system occur in a mainstream educational environment?
    a. Yes
    b. No→ exit survey
3. Was the student with hearing loss who used the personal FM system in a grade between Kindergarten and 8th grade?
    a. Yes
    b. No→ exit survey
4. When was your most recent experience with a personal FM system in the classroom?
    a. This year.
    b. Last year.
    c. Within the past 5 years.
    d. 5-10 years ago.
    e. More than 10 years ago.

Content questions

The following questions are interested in obtaining more information about the use of personal FM systems in the classroom. A personal FM system is one that consists of a transmitter/ microphone used by the teacher (usually worn around the neck or clipped on to the shirt) and a receiving device worn on the ear of a student or connected to a student's hearing aids. This allows the teacher's voice to be sent directly to the individual child's ear and helps overcome the negative effects of background noise and distance on the speech signal. For the purposes of this survey, use of the term "FM system" will always be referring to a personal FM system utilized by one student, as opposed to a sound field or speaker system set up around the classroom and utilized by all students.

Please answer honestly. The purpose of this study is to identify topics related to personal FM system use in the classroom that need to be addressed with teachers in more detail by the audiology community. This will help improve the quality of use, make teachers more comfortable with the devices, and thus help maximize the education of children with

hearing loss. You are encouraged to add comments when applicable in order to provide more accurate information about your experiences with FM systems.

Thank you for your time!

Daily Implementation and Consistency of FM System Use:

5. In your experience, does the student with hearing loss who requires a personal FM system consistently wear the device on a daily basis?
6. In a typical week, what percentage of the time that you spend/ spent with the student do they wear the FM system?
    a. 0% of the week
    b. 25% of the week
    c. 50% of the week
    d. 75% of the week
    e. 100% of the week
7. In your experience, does the student take responsibility to ensure that the FM system is being worn at all times during classroom instruction, is functioning properly, and is charging every night?
8. Do you remind the student to use the FM system if you see that it is not being worn?
9. In your experience, do you feel that the student would tell you if the FM system stopped working at some point during the school day?
10. How often do you experience technical issues with the FM system that result in the student not being able to use the device for a period of time?
    a. Never
    b. Once a year
    c. 2-3 times per year
    d. Once a month
    e. 2-3 times per month
    f. Once a week
    g. 2-3 times per week
11. In your opinion, what is a common reason that students often do not use the FM system every day (choose all that apply)?
    a. They do not feel they are benefitting from the device
    b. The device is broken
    c. Social reasons- classmates are not accepting of the student wearing the device
    d. The student's own negative feelings towards the device
    e. Parents tell their child it does not need to be worn
    f. Teachers forget to remind the student to wear the FM system
    g. The student "forgets" their receivers at home, in a locker, etc.
    h. Other (please specify)
12. In your opinion, do you see a trend of younger children being more willing to use an FM system and stopping or decreasing use as they get to older grades?

Teacher Attitudes Towards the Use and Benefit of FM Systems in the Classroom:

13. Do you believe that personal FM systems are beneficial to students with hearing loss in your classroom during instruction?
14. In your experience, do you believe the student with hearing loss in your classroom performs better academically when using the personal FM system compared to not wearing it?
15. In your experience, do you believe the student with hearing loss has better social interaction while wearing the personal FM system compared to not wearing it?
16. Does it bother you to wear the FM transmitter (microphone) during classroom instruction everyday?
17. Do you think it is important for the student to have the personal FM system at all times during classroom instruction?
18. Do you believe it is the student's or teacher's responsibility to ensure that the personal FM system is being worn at all times during classroom instruction?
    a. Student's responsibility
    b. Teacher's responsibility
    c. Student's responsibility, but teacher should help remind
19. Do you believe it is the student or teacher's responsibility to ensure that the personal FM system is functioning properly each day?
    a. Student's responsibility
    b. Teacher's responsibility
    c. Student's responsibility, but teacher should help remind

Teacher Knowledge of the FM system components and troubleshooting methods:

20. Were you provided with training on personal FM system use, troubleshooting, etc. before beginning use? If so, do you believe it was beneficial?
    a. No, I was not provided with any FM system training
    b. Yes, I was provided with training, but I do not think it was beneficial
    c. Yes, I was provided with training, and I think it was beneficial
21. Do you receive periodic training on personal FM systems, or have a reliable contact that you can ask questions to?
    a. Yes
    b. No
    c. No, but this would be helpful.
22. Please check the following areas that were covered with you during a training session before beginning use with the personal FM system:
    a. Basic impact of hearing loss on speech understanding
    b. Purpose of FM system (increase the ratio of speech to background noise)
    c. Benefit of FM system use in the classroom for children with hearing loss
    d. Expectations about the benefits and limitations of the device
    e. Identification of the teacher- and student-worn components

f. Connection of receivers to student's hearing aids
g. Appropriate use of device and features (purpose of various buttons)
h. When to use and when not to use the device
i. Listening check to ensure adequate function of the FM system
j. Daily charging and storage protocol for the device
k. Basic troubleshooting techniques that can be done in the classroom
l. Person who should be contacted in the case that the device needs repaired
m. I did not receive FM system training
n. Other (please specify)

23. Children with more mild degrees of hearing loss don't need to wear the FM system as consistently as those with more severe degrees of hearing loss.
    a. True
    b. False
24. Do you know where the child's FM system should be stored each night?
25. Do you know how to charge the FM system?

Appendix B: RMHAT Guidelines

In the current study, Question #22 of the survey states: "Please check the following areas that were covered with you during a training session before beginning use with the personal FM system". The following comparison identifies the topics that are listed in the AAA RMHAT Clinical Practice Guidelines (AAA, 2008) and are suggested to cover with teachers during a training session prior to beginning use with a personal FM system for a child with hearing loss. The comparable issues that were provided to teachers as optional answers for Questions #22 in the current survey are shown next to each RMHAT Guideline topic to demonstrate the interpretation and origin of each.

RMHAT Clinical Practice Guidelines (AAA, 2008)	**Question #22**
Basic implications of hearing loss	Basic impact of hearing loss on speech understanding
Basic function of the device	Purpose of FM system (increase the ratio of speech to background noise)
Appropriate use of device and features	Appropriate use of device and features (purpose of various buttons)
Expectations: benefits and limitations of the device including when to use and when not to use	Benefit of FM system use in the classroom for children with hearing loss
	Expectations about the benefits and limitations of the device
	When to use and when not to use the device
Listening check and basic troubleshooting	Identification of the teacher- and student-worn components
	Connection of receivers to student's hearing aids
	Listening check to ensure adequate function of the FM system
	Basic troubleshooting techniques that can be done in the classroom
Reporting of a suspected malfunction	Person who should be contacted in the case that the device needs repaired
Advocacy	
Classroom orientation to HAT	Daily charging and storage protocol for the device

(List taken from American Academy of Audiology, *AAA clinical practice guidelines: Remote microphone hearing assistance technologies for children and youth birth–21 years*, 2008)

Appendix C: Recruitment Materials

Initial recruitment email

As a teacher in a mainstream school in the Columbus area, I am asking you to participate in a short survey that seeks to gain more information about the consistency of personal FM system use in the classroom and teacher's attitudes and knowledge of the technology. Personal FM systems are assistive listening devices used to help hearing-impaired children better understand speech and hear the teacher's voice more clearly. The teacher's voice is transmitted from a body worn microphone, to the receivers worn on the student's ears. The goal of this study is to identify topics regarding personal FM systems that need to be addressed more thoroughly with teachers by the audiology community in order to help improve the education of children with hearing loss and make teachers more comfortable with the use of this device.

I am a Doctor of Audiology student at The Ohio State University and am collecting this data as part of my Capstone Research project. If you agree to participate, I expect this survey should only take 10 minutes or less to complete. Your participation in this project is voluntary. If you agree to volunteer, you may change your mind and discontinue participation in the short survey at any time without prejudice or explanation. Your anonymity will be strictly guarded and responses will not be linked to individual respondents. I plan to share my findings with the Audiology and Education communities through presentation.

***Survey Link

For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

Thank you for your time!

Anna Fry
Doctor of Audiology student, Class of 2014
The Ohio State University
fry.168@osu.edu

Gail Whitelaw, Ph.D., CCC-A
Clinical Director of Audiology
The Ohio State University
whitelaw.1@osu.edu

Follow-up email

If you have not already done so, please consider completing this quick survey about Personal FM System use in the classroom. **We are also using this survey to get an idea of how many teachers actually have used the device, so even if you have never used a personal FM System, please answer only the first question of the survey, as this is helpful information for the data we are collecting as well!**

The survey will close on **Monday, April 15, 2013** at midnight. It should take no longer than 10 minutes to complete.
**Survey Link

The data being collected from this survey is part of my Audiology Capstone Research project at the Ohio State University. Your experiences and opinions are very valuable to us and for helping improve the education of children with hearing loss and making teachers more comfortable with the use of this device.

Your anonymity will be strictly guarded and responses will not be linked to individual respondents. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

Thank you very much for your time!

Anna Fry
Doctor of Audiology student, Class of 2014
The Ohio State University
fry.168@osu.edu

Gail Whitelaw, Ph.D., CCC-A
Clinical Director of Audiology
The Ohio State University
whitelaw.1@osu.edu

Final Reminder email

Hello!

I wanted to send a final request for you to consider completing a short survey on personal FM system use in the classroom. Information gained from this study will highlight areas regarding hearing loss and FM systems that need to be addressed with the educational community in more detail. Ultimately, this can help make teachers more comfortable with the use of this technology, and therefore help to improve the education of children with hearing loss.

If you have already done so, thank you very much for your input and you can disregard this message! The survey should take no more than 10 minutes and will close at the end of the day on **Monday, April 15.**

**Survey Link

The data being collected from this survey is part of my Audiology Capstone Research project at the Ohio State University. As a teacher in a mainstream classroom, your experiences and opinions are very valuable to us.

Your anonymity will be strictly guarded and responses will not be linked to individual respondents. For questions about your rights as a participant in this study or to discuss other study-related concerns or complaints with someone who is not part of the research team, you may contact Ms. Sandra Meadows in the Office of Responsible Research Practices at 1-800-678-6251.

Thank you very much for your time!

Anna Fry
Doctor of Audiology student, Class of 2014
The Ohio State University
fry.168@osu.edu

Gail Whitelaw, Ph.D., CCC-A
Clinical Director of Audiology
The Ohio State University
whitelaw.1@osu.edu